CHAPTER 5
STRUCTURES FOR BULK MATERIALS

5-1. General

Design of structures for bulk materials will include consideration of the special characteristics of the material being handled or stored. Design values for material density, maximum conveyor slopes, etc., will be carefully determined, and consideration will be given to the need for special structural construction or supports to assure the smooth flow of materials into or out of the tanks or bins used for bulk storage.

5-2. For granular materials

a. Silos, bins, and bunkers. Design of these types of structures, if constructed from steel or other metal, will be in accordance with procedures presented in Design of Welded Structures by Blodgett and the Structural Engineering Handbook by Gaylord & Gaylord. If constructed of concrete, design of these types of structures will be in accordance with ACI 313, Handbook of Concrete Engineering by Fintel, and Silos: Theory & Practice by Reimbert & Reimbert.

b. Conveyor system supports. Design of conveyor system supports will be in accordance with relevant publications of the Conveyor Equipment Manufacturers Association (CEMA) such as Belt Conveyors for Bulk Materials and cited references. Design loads will be determined from ANSI A58.1 where applicable and as furnished by the conveyor system manufacturer. The design agency will verify that appropriate impact factors have been included in loads provided by the conveyor system manufacturer.

5-3. For liquid materials

a. General. Structures associated with the storage and handling of bulk liquid materials will be designed in accordance with the codes and standards applicable to the type of material being handled. Earthquake loads will be in accordance with TM 5-809-10/NAVFAC P-355/AFM 88-3, Chapter 13. Among the codes and standards applicable to the design of structures for bulk liquid materials are AWWA D100, AWWA D103, AWWA D110, AWWA D120, API 650, and the Structural Engineering Handbook by Gaylord & Gaylord.

b. Materials. Selection of materials of construction for tanks in which liquids are to be stored will consider the environmental conditions to which the tank will be exposed as well as the properties of the liquid being stored. In general, inherently corrosion-resistant materials should be selected for buried tanks although steel tanks will be acceptable if properly protected against corrosion. See Steel Tank Institute (STI) sti-P3 Specification and Manual for External Corrosion Protection of Underground Steel Storage Tanks for guidance in protecting this type of tank.

c. Tanks. Design of structural systems for tanks will include the necessary interfaces between the supporting structure or base and the tank itself. For that reason, it is important that the agency designing the support structure be familiar with the specifications applicable to the tank.

(1) References. The following are amoung the references applicable to structural design fot tanks in addition to those indicated above:

(a) Department of the Navy NAVFAC DM-22.

(b) American Petroleum Institute (API) Publications 1615 and 1632 and Standard 2000.

(c) American Iron and Steel Institute (AISI) Steel Tanks for Liquid Storage.

(d) Steel Tank Institute (STI) Dual Wall Underground Steel Storage Tanks, Recommended Practice for Optional Interior Corrosion Control System for Steel Tanks, and Guideline for Underground Piping for Fuel Storage Tanks.

(e) Portland Cement Association (PCA) IS003.02D and 15072.1D.

(f) American Concrete Institute (A CI) 344R, 344R-T, 344R-W, and 35O R.

(g) Precast/Prestressed Concrete Institute (PCI) JR-334.

(2) Additional considerations. Additional considerations apply to tank design depending on the type of tank and other factors as discussed in the following.

(a) Elevated tanks. Design of elevated tanks will include consideration of lateral loads due to earthquake as set forth in TM 5-809-10/NAVFAC P-355/AFM 88-3, Chapter 13. For individual leg foundations, the weight of the foundation alone (not considering weight of the earth cover) will provide a minimum safety factor of 1.2 against uplift, overturning, and sliding.

(b) Ground-level tanks. The provisions of NAVFAC DM-7.2 will apply to the design of foundations for ground level tanks. Although ring beams are required only for tank foundations in seismic zones 3 or 4, this type of construction or comparable provisions necessary to prevent frost heave will be made in all areas. Consideration will be given to the need for and alternate means of accomplishing corrosion protection of the underside of the tank floor plates.

(3) Below-grade. Design of below-grade or buried tanks will consider the potential bouyancy of the tank, and a suitable ballast slab or other anchoring system will be provided to assure that the tank will not float when the dead weight of the empty tank and soil cover directly over the tank are insufficient to prevent flotation. Dual walled tanks will be used consistent with requirements of the Environmental

Protection Agency and local agencies who would have jurisdiction for privately developed projects.

(a) Earth cover. Earth cover will be provided over the top of tanks in accordance with frost penetration requirements (considering concrete distribution slab thickness) but will be not less than 2 feet 6 inches.

(b) Backfill material. Backfill for underground tanks will include a &inch course of inert sand or fine gravel placed against exposed exterior surfaces.

(4) Concrete tanks and reservoirs. Tanks and reservoirs designed to contain fresh water and other non-deteriorating substances will have a clear cover over the reinforcement of not less than 1-1/2 inches for slabs and 2 inches for beams and girders or shall be constructed using conventional depth of cover but with surface sealants or coated reinforcing or both. A minimum temperature differential of 40 degrees F will be assumed to exist between inside and outside faces of tank walls.

(a) Reinforced concrete tanks. Design of reinforced concrete tanks will be in accordance with PCA 15003.02D and 15072.01D. Other acceptable standard design methods or concepts may also be used.

(b) Prestressed concrete tanks. Design of prestressed concrete tanks will be in accordance with ACT 344R. Other current acceptable methods may also be used.

(5) Petroleum, oil and lubricant (POL) tanks and facilities. Design of POL tanks will be in accordance with API 650.

(6) Water storage tanks. Design of water storage tanks will be in accordance with applicable American Water Works Association publications but subject to specific design restrictions as set forth above.

(7) Tanks for other than oil or water. The basis for design of steel tanks will be API 650, but special considerations related to the product stored in the tank must be accounted for. Steel tanks to store liquefied gases at or near atmospheric pressures will be designed in accordance with API 620. Storage of corrosive solutions and the effects of temperature in conjunction with corrosive solutions will be considerations in selecting tank materials.